58 mounted in the carrier for rotatably supporting the planet gears. The carrier **30** also includes a plurality of apertures, one of which is shown at **76**, circumferentially intermediate the planet gears **28**.

The sun gear assembly **50** is an input gear assembly since it is the component of the planetary gear train that receives rotary motion and torque from the powerplant **2** (FIG. **1**). The planet gear assembly **56** is an output gear assembly since it is the component of the planetary gear train that transmits rotary motion and torque out of the planetary gear train to the fan.

The torque frame **10** completes the connection from the planet carrier **30** to the bladed propulsor represented by fan blades **4** mounted in the periphery of a disk **70** whose bore **72** is adapted, as by a spline **71**, to mate with the torque frame and rotate therewith. The torque frame has a circumferentially discontinuous first end **9**, terminating in a series of discrete and therefore independently flexible arms **78**, and a second end **11** spaced axially from the first end. Each arm has a proximal end **29** integral with the torque frame and a distal end **34**. Each arm projects through a corresponding aperture **76** in the forward end plate **31**. At each of a plurality of locations circumferentially intermediate the planet gears, a joint **79** connects the carrier to the distal ends of the torque frame arms **78**. At the distal end of each arm, the longitudinal centerline **35** of each arm is at a radius at least as great as that of the planet gear axes **32**. Consequently, at least a portion of the distal end of each arm is at a radius greater than that of the planet gear axes. Near its second end, the torque frame **10** is connected to the rotating disk **70**.

During operation, rotary motion of the fan blades **4** is resisted by forces generated when the fan blades interact with the ambient air. Because these resistive forces act at a finite distance from the central axis **14**, their cumulative effect is to create a torque that must be overcome by the power plant. The joint configuration by which torque is communicated through the planet gear assembly to the torque frame is the central feature of the present invention and is best appreciated in contrast to the conventional arrangement depicted in FIG. **3**.

FIG. **3** illustrates a geared drive system of conventional construction. As with the present invention, the geared drive system includes a ring gear **26'**, a sun gear **24'**, planet gears **28'**, a planet carrier **30'** and a torque frame **10'**. The planet carrier **30'** has a forward end plate **31'** and a rear end plate **33'**. Each planet gear is rotatably supported in the carrier by a journal **58'**, and each journal has a central axis **32'** which is the axis of rotation of the associated planet gear. For clarity, only one journal is shown and other structure connecting forward and rear end plates **31'** and **33'** has been omitted. Similarly, the fan blades are not shown; instead they are represented by the torque T that they impose on the drive system. The powerplant rotates the sun gear, planet carrier, and torque frame in direction R, opposite to the direction of the torque load T. Typical of the prior art, the torque frame is secured to the planet carrier so that the carrier experiences at least some of the torsional deflection occurring between the powerplant and the load. The torque frame is shown as a simple shaft secured to one end plate of the planet carrier. Many other constructions are possible including those in which the torque frame is integral with and indistinguishable from the carrier, however, they all share the characteristic that they transfer torsional deflection into the planet carrier. Consequently, the forward end plate **31'** and rear end plate **33'** of the planet carrier are circumferentially displaced relative to each other through an angle Θ. Each journal **58'** is similarly deflected as shown in phantom so that the planet gear rotational axis **32'** assumes a deflected orientation **32"**. Since the sun gear and ring gear axes remain parallel to the central axis **14'** while the planet gear axes have become skewed or nonparallel relative thereto, the mesh between the planet gears and the sun gear, and the mesh between the planet gears and the ring gear deviate from the mesh that would have occurred had the axes remained parallel. If allowances are made in the gear tooth design to accommodate the effects of nonparallelism, they will only be completely effective at a single operating condition. Reinforcing the planetary gear train as by stiffening the carrier to minimize torsional deflection or by strengthening the gear teeth generally involves increased weight, cost, or physical size, all of which may be unacceptable.

The present invention isolates the planet carrier from the effects of torsional deflection by transferring torque from the carrier to the torque frame such that substantially all of the torsional deflection is experienced in the torque frame, and substantially none of the torsional deflection occurs in the planet carrier. One embodiment of the unique interface responsible for this isolation is illustrated in FIG. **4** which shows the forward end plate **31** and rear end plate **33** of the carrier **30** abuttingly mated together by carrier assembly bolts **90** (only two of which are shown). As best seen in FIGS. **6** and **7**, the abutting contact extends over a substantial portion of the circumference of the carrier. The mating surfaces of the carrier end plates define shoulders **93**, and the forward end plate **31** of the carrier includes a series of apertures **76** circumferentially intermediate the sun gears. At corresponding circumferential locations, the torque frame **10** is circumferentially discontinuous, terminating in a series of discrete arms **78**. Each arm extends axially through the apertures to a location axially intermediate the forward end plate **31** and rear end plate **33** of the carrier where each arm is connected to the carrier by a joint **79** mechanically intermediate the torque frame and the carrier. Joint **79** is a spherical bearing **80** comprising a housing **82** with a flange **83** and a truncated spherical ball **84** trapped within the housing, but capable of pivotable motion about both a radial axis **86** perpendicular to the plane of the illustration and a tangential axis **88**. A housing attachment nut **92** threads onto the end of the housing opposite the flange **83** to clamp the housing **82** onto the shoulder **93** to secure the spherical bearing to the carrier. An attachment bolt **96** extends through a substantially axial first hole **98** in each torque frame arm and a second hole **99** in the ball. The attachment bolts **96** and mating nuts **94** effect the connection of each torque frame arm **78** to the articulating balls **84** and hence to the carrier **30**.

Under torsional load, the torsional deflection or twisting of the torque frame is manifested as bending of the torque frame arms **78** from their undeflected position through an angle Θ' to their deflected position **78"** shown in phantom. The pivotability of the ball **84** about the radial axis **86** and the bending of the torque frame arms isolate the carrier **30** from torsional deflections.

Alternative pivotable connections between the carrier and the torque frame are equally suitable. FIG. **5** shows one such connection where each torque frame arm **78** includes a radially extending hole **100** fitted with a pressed-in bushing **102**. The carrier **30** includes corresponding holes **101**, also fitted with bushings **103**. A trunnion **104**, radially disposed in the holes **101** in the carrier **30** and retained therein by a trunnion retention screw **105**, extends through the hole **100** in the torque frame arms **78** to pivotably join the carrier and the torque frame. Under operational load, the torque frame arm **78** and the bushing **102** pivot about radial axis **86** while